GEOLOGY/ GEOMORPHOLOGY

Physiographic Region

The Spring River Tributaries Watershed lies within the Salem Plateau Subdivision of the Ozark Plateau. The Salem Plateau is a heavily dissected plateau with upland elevations of between 1,000 and 1,400 feet (MDNR 1986). Local relief on the uplands is between 100 to 200 feet. In areas of deeply intrenched valleys, local relief ranges between 200 to 500 feet. Elevations within the Spring River Tributaries Watershed range between 1,200 feet above sea level in the uplands to less than 500 feet above sea level in the lower portions of the watershed within Missouri, specifically the Warm Fork of the Spring River at the state line.

Geology

The surface of the Spring River Tributaries Watershed occurs almost entirely within Jefferson City Dolomite. The only exception to this is a two mile section of the Warm Fork occurring within the sandstone and cherty dolomite of the Roubidoux Formation which underlies the Jefferson City Formation (Figure Ge01)(MSDIS 1998 and MDNR 1994). Due to the nature of the surface geology of the watershed as well as climatic conditions, there are many karst features present here including sink holes, losing streams, and springs (MDNR 1986 and MDNR 1994). The two most prominent karst features within the watershed are the Grand Gulf (Missouri), and Mammoth Spring (Arkansas). The Grand Gulf, part of Grand Gulf State Park, is a large sinkhole into which Bussel Branch, a third order stream, drains. Successful dye traces have shown that much of this flow resurfaces at Mammoth Spring in Arkansas which has an average discharge of 300 cfs making it the 2nd largest spring in the Ozarks (MDNR 1994). This is despite the fact that streams of the watershed do not incise the Gasconade Dolomite Formation which is the top formation of the three formations in which most of the largest springs in Missouri occur (MDNR 1994; Vineyard and Feder 1974).

Soils

The Spring River Tributaries Watershed occurs within the Ozark Soils Region. Allgood and Persinger (1979) describe the Ozark Soils Region as "cherty limestone ridges that break sharply to steep side slopes of narrow valleys. Loess occurs in a thin mantle or is absent. Soils formed in the residuum from cherty limestone or dolomite range from deep to shallow and contain a high percentage of chert in most places. Some of the soils formed in a thin mantle of loess are on the ridges and have fragipans, which restrict root penetration. Soil mostly formed under forest vegetation with native, mid-tall and tall grasses common in open or glade area."

The following is a list of soil associations found in the Spring River Tributaries Watershed in Missouri: Lebanon-Hobson-Clarksville, Captina-Macedonia-Doniphan-Poynor, Captina-Clarksville-Doniphan, Wilderness-Clarksville-Coulstone, Hartville-Ashton-Cedargap-Nolin (alluvial), (Allgood and Persinger 1979).

Stream Mileage, Order and Permanency, Springs

Using United States Geological Survey (USGS) 7.5 minute topographic maps, a total of 77 third order and larger streams were identified within the Spring River Tributaries Watershed within Missouri (Table Ge01, Figures Ge02, and Ge03). These streams account for approximately 392 stream miles. Of the 77

third order and larger tributaries within the watershed, 54 are third order, 16 are fourth order, 5 are fifth order, and 2 are sixth order. Table Ge02 shows length of stream per order for fourth order and larger streams within the watershed.

Drainage areas have been determined from digital raster graphic (drg) versions of USGS 1:100,000 and 1;24,000 scale topographic maps. The drainage area of the Spring River Tributaries Watershed in Missouri is 307,200 acres or 480 square miles. The watershed has been divided into six subwatersheds (not to be confused with the 14 digit hydrologic units or the drainage sections which are used in this document for display purposes) based on drainage areas accounting for ≥ 5% of the total drainage area of the Spring River Tributaries Watershed (Figure Ge04). The Warm Fork Subwatershed is the largest subwatershed within the Spring River Tributaries Watershed. It encompasses a total of 265 square miles and includes most of the major populated places within the watershed including the cities of West Plains and Thayer, Missouri.

Using United States Geological Survey (USGS) 7.5 minute topographical maps, the extent of permanent and intermittent flow has been determined for third order and larger streams within the Spring River Tributaries Watershed. (Table Ge03, Figure Ge02, and Ge03). Of the 392 miles of third order and larger streams, 99.8 miles (25%) have permanent flow. The Warm Fork of the Spring River has the longest length of permanent stream at 22.6 miles. Spring Creek below Arrowhead lake has the highest percentage of permanent stream versus total length at 100 percent.

In an effort to further delineate stream flow as well as the cold water resource within the watershed, stream crossing temperature checks were performed during the summers of 1996, 1997, and 1998 by Missouri Department of Conservation Ozark Region Fisheries personnel.

Results from this study generally corresponded with the USGS 7.5 minute topographical maps with a few exceptions. One site on Howell Creek below Big Gressy Creek went completely dry in 1997. However, a site above and below had permanent pools for all years. Another notable exception is the fact that permanent water appears to exist in some headwater streams within the watershed which were previously shown to be intermittent on USGS maps. Two examples of this are the North Fork of Howell Creek and Galloway Creek (Legler, personal communication). Flows from both streams are eventually lost to the groundwater system. These represent somewhat unique features given their headwater characteristics in addition to the fact that they exist in an area highly influenced by karst topography. In order to fully appreciate the significance of these small reaches of permanent headwater streams further study will be required. Figure Ge05 shows the remaining flow data including other additional sites with permanent flow. It is important to note that sites which were found to be dry in a single year were not checked in proceeding years. Additionally, sites found to be dry the first year are not included in Figure Ge05.

The karst nature of the Spring River Tributaries Watershed is evident in the amount of losing streams within the watershed. There are 78.5 miles of stream within the watershed which are designated as losing streams by MDNR (1996)(Table Ge04). This is important to note when considering potential point and nonpoint pollution effects not only within the immediate watershed, but also on the groundwater system and thus well systems as well as other watersheds. Dye traces conducted within the watershed and adjoining watersheds by various state and federal agencies as well as one private individual have shown that much of the water lost to the ground water network in the watershed resurfaces at Mammoth Spring at the head of the Spring River in Arkansas (MDNR 1995, 1996). Two dye traces which had injection points outside the watershed also were recovered at Mammoth Spring (Figure Ge06). This illustrates the

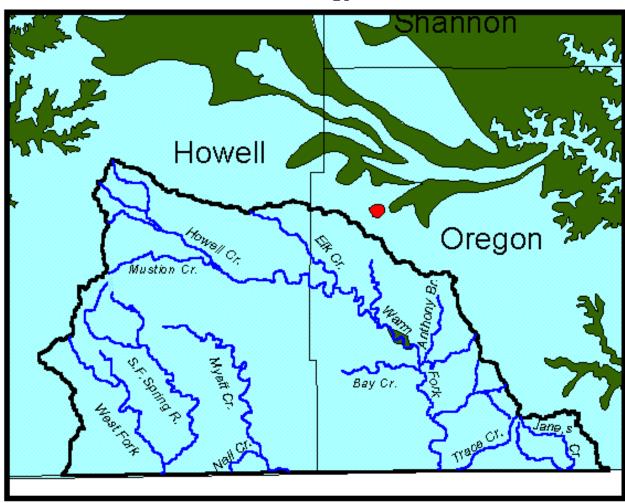
point that surface ground water system boundaries do not always coincide with surface watershed and subwatershed boundaries.

There are 17 named springs within the Spring River Tributaries Watershed as determined by data obtained from United States Geological Survey (USGS) Geographic Names Information System (GIS) Database (Table Ge05 and Figure Ge07). The only springs within the watershed listed by Vineyard and Feder (1974) are Lost Spring and Mammoth Spring in Arkansas. Lost Spring has a discharge of .02 cfs (13,000 gallons/day), while Mammoth Spring, the second largest spring in the Ozarks has a discharge of 240 cfs (155,000,000 gallons/day). Little information regarding flow rates, chemical characteristics, or recharge area appears to be available relating to the remaining springs. However, some of these springs within the watershed are believed to have significant flow. The Warm Fork receives enough spring influence below Warm Fork Spring to be designated for Cold-Water Sport Fishery by the Missouri Department of Natural Resources (MDNR 1996). Data from long term temperature recorders (thermographs) indicate significant spring influence in other stream reaches as well (Figure Hc02 and Hc03). Given the influence on aquatic habitat demonstrated by some springs as well as the karst nature of this watershed, these springs represent a significant characteristic of the subwatershed and should be studied in more depth.

Channel Gradient

Gradient Plots were digitized from 7.5 minute USGS topographical maps for all fourth order and larger streams within the Spring River Tributaries Watershed in Missouri (Table Ge06). Composite gradient graphs were generated for fifth order and larger streams within the watershed. The Warm Fork of the Spring River/Howell Creek (6th order) have the lowest overall stream gradient at approximately 11 feet/mile; while stream EPW070 (4th order) has the highest overall stream gradient at approximately 79 feet/mile.

Spring River Tributaries Watershed Geology



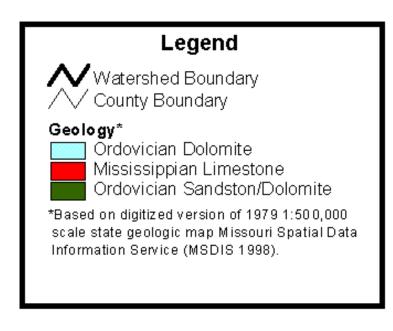
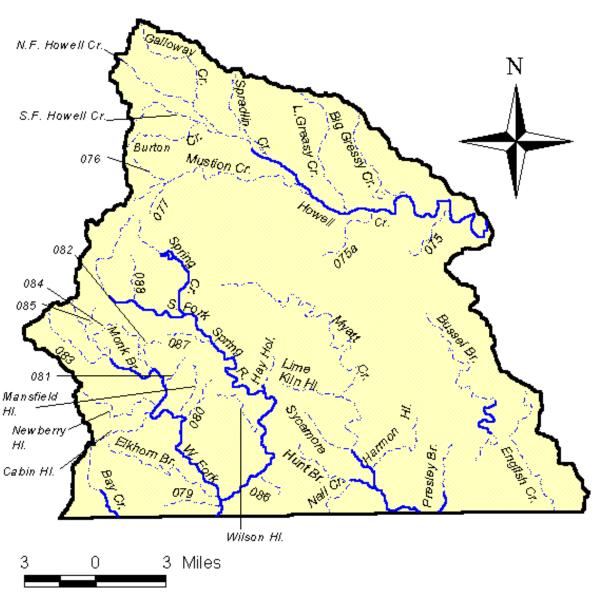


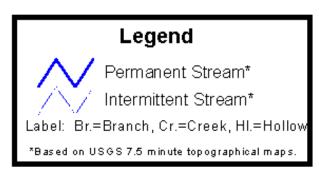


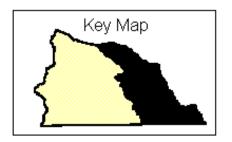
Figure Ge02.

Spring River Tributaries Watershed

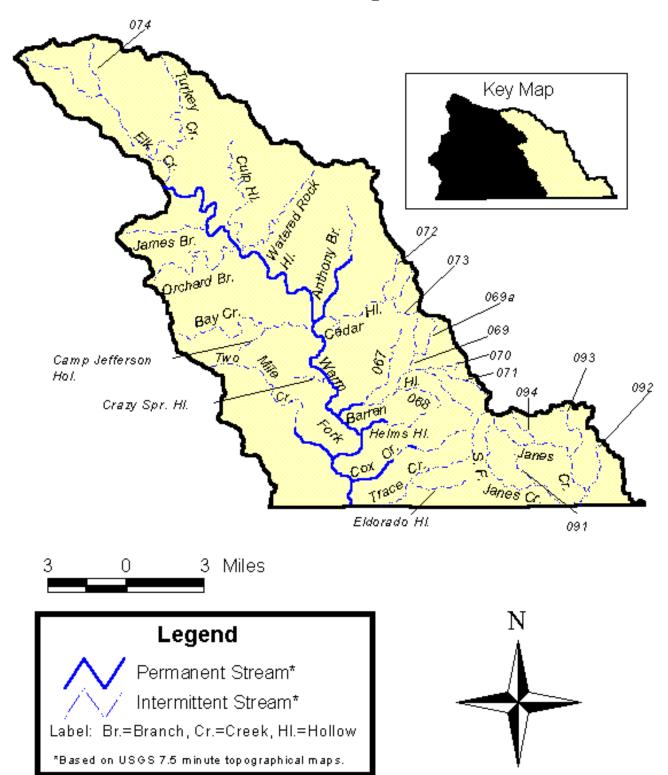
West Drainage Section Third Order and Larger Streams



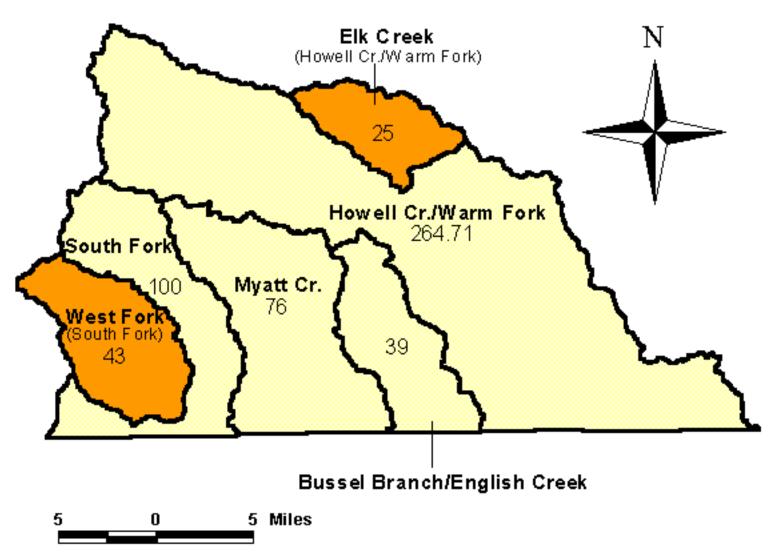




Spring River Tributaries Watershed East Drainage Section Third Order and Larger Streams

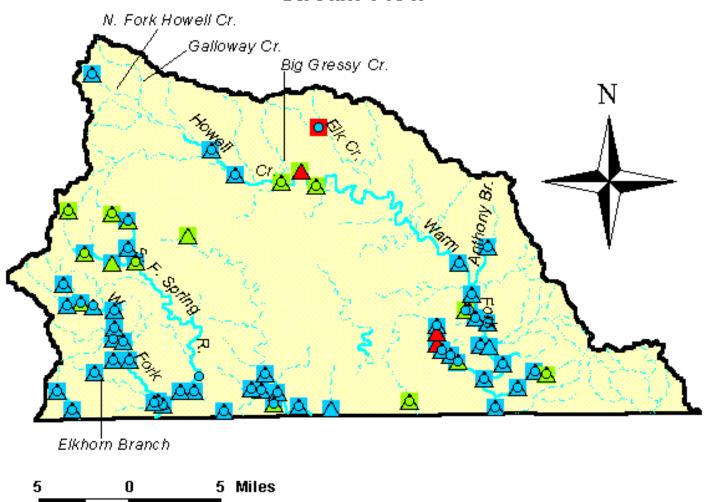


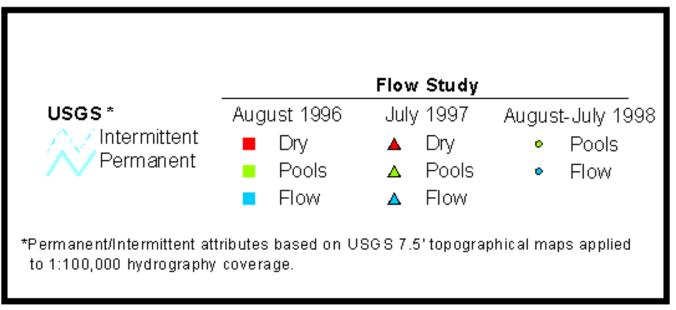
Spring River Tributaries Watershed Subwatersheds



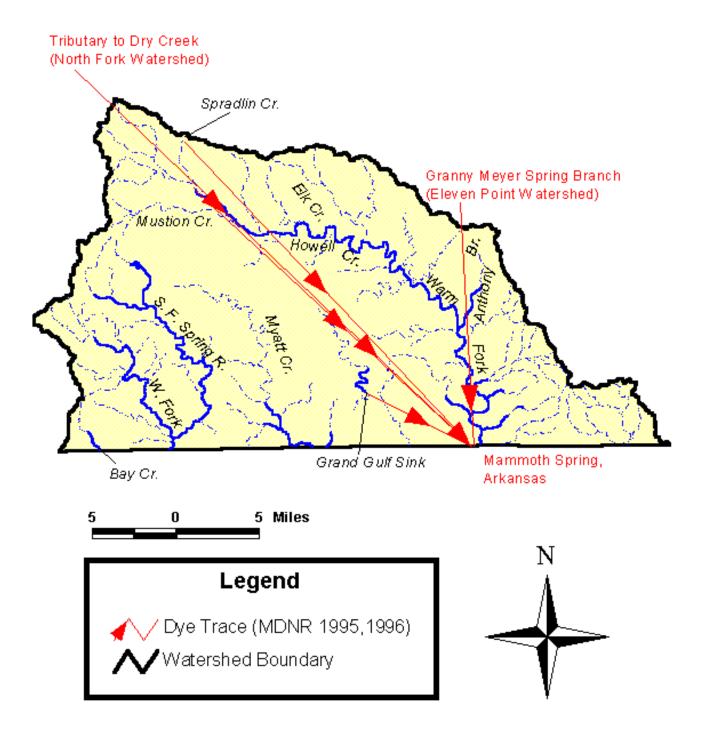
Shaded areas indicate that subwatershed is a part of larger subwatershed (indicated in parenthesis) and included in estimated drainage area of larger subwatershed. Drainage area given in square miles.

Spring River Tributaries Watershed Stream Flow

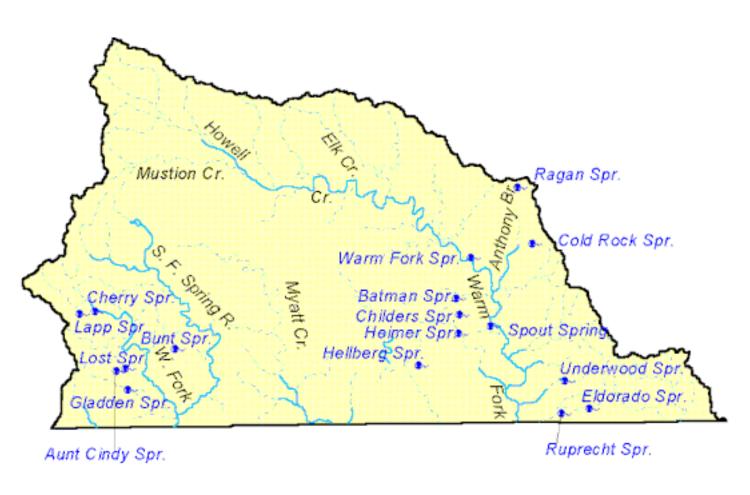


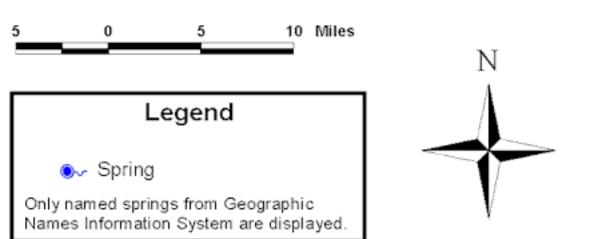


Spring River Tributaries Ground Water Movement

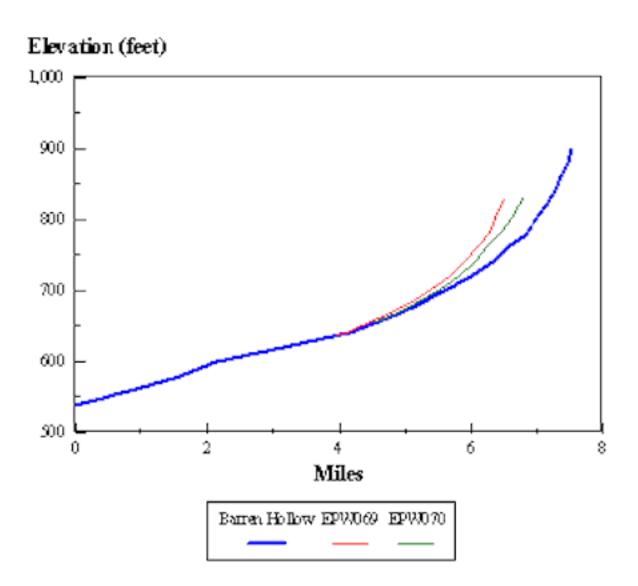


Spring River Tributaries Watershed Springs

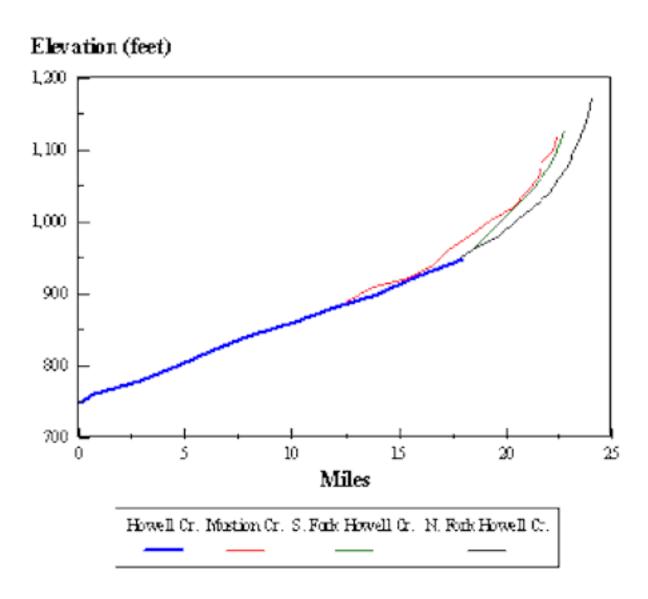




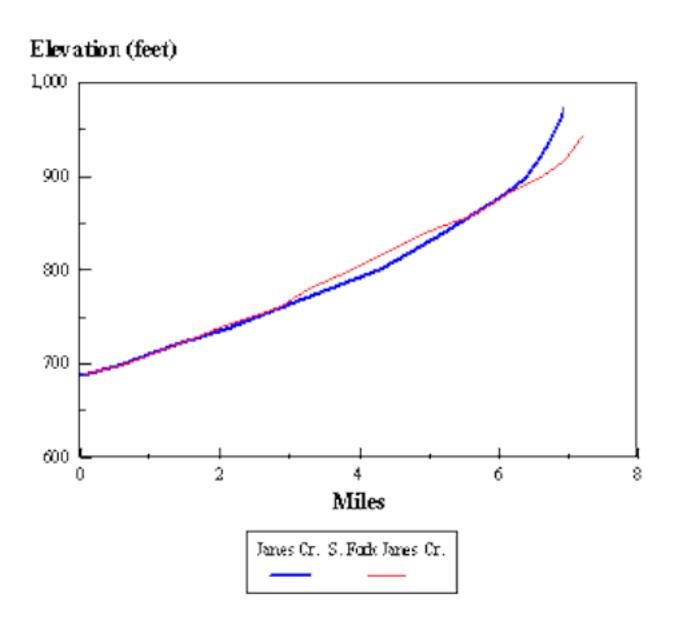
Barren Hollow



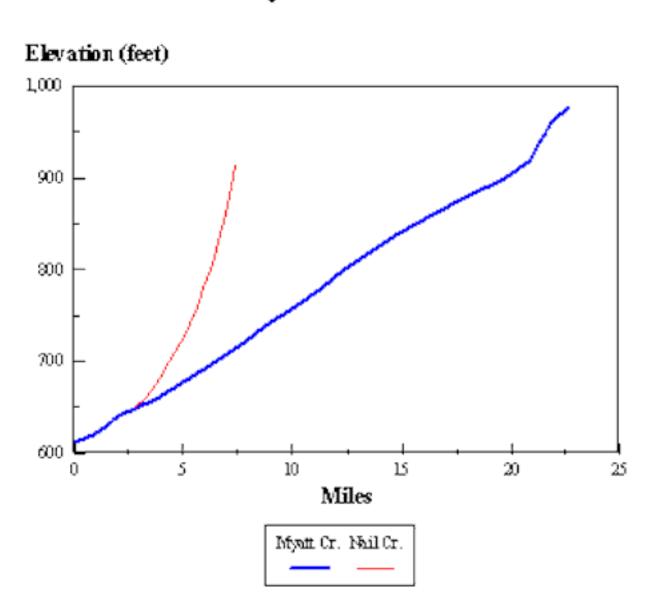
Howell Creek



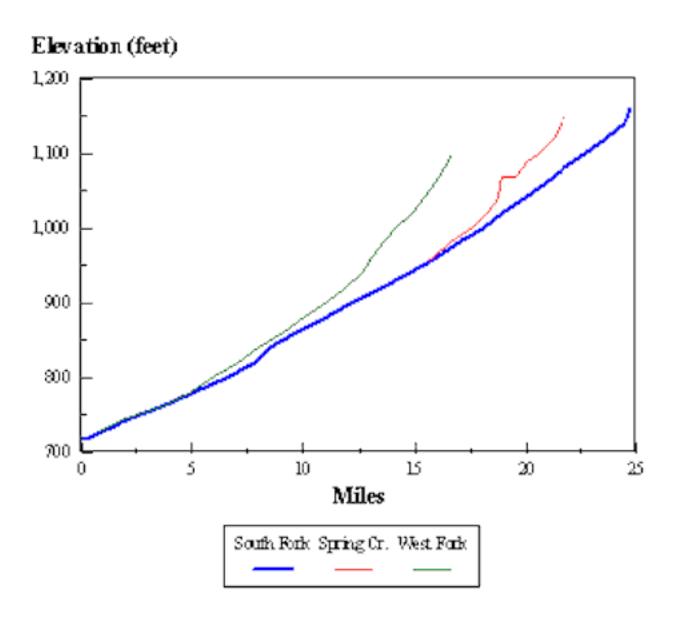
Janes Creek



Myatt Creek



South Fork Spring River



Warm Fork Spring River

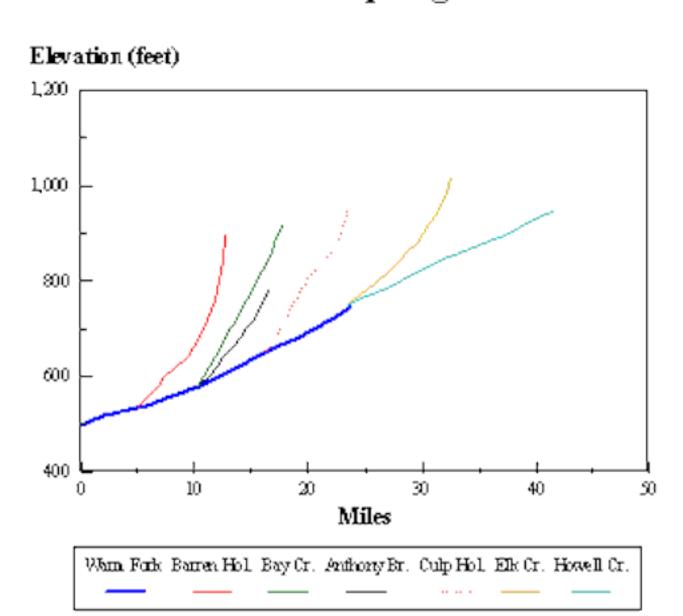


Figure GE 14. Gradient plot for West Fork and major tributary.

West Fork

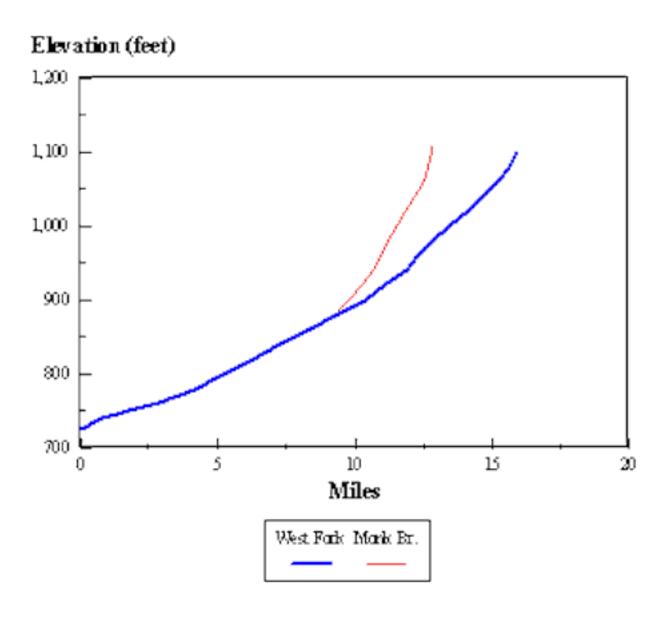


Table Ge01. Third order and larger streams of the Spring River Tributaries Watershed in Missouri as determined from 1:24,000 USGS topographical maps.

Stream Name	Order	7.5' Quad (mouth)	Name and Order Downstream Link
Jane's Creek	5*	Myrtle*	Spring R. AR
South Fork Jane's Cr.	4	Myrtle	Jane's Cr. 5
EPW090	3	Couch	S.F. Jane's Cr. 4
EPW091	3	Couch	S.F. Jane's Cr. 4
EPW092	3	Myrtle	Jane's Cr. 4
EPW093	3	Couch	Jane's Cr. 4
EPW094	3	Couch	Jane's Cr. 3
Trace Creek	4*	Mammoth Springs, AR	Spring R. AR
Eldorado Hollow	3	Couch	Trace Cr. 4
EPW089	3	Couch	Trace Cr. 4
Warm Fork of Spring R.	6*	Thayer*	Spring R. AR
Cox Creek	3	Thayer	Warm Fork 6
Two Mile Creek	3	Thayer	Warm Fork 6
Helms Hollow	3	Thayer	Warm Fork 6
Barren Hollow	5	Thayer Warm Fork 6	
EPW067	3	Thayer Barren Hollov	
EPW068	3	Couch	Barren Hollow 5

EPW069	4	Couch	Barren Hollow 5
EPW069a	3	Couch	Epw069 4
EPW070	4	Couch	Barren Hollow 4
EPW071	3	Couch	EPW070 4
Crazy Spring Hollow	3	Thayer	Warm Fork 5
Bay Creek	4	Thayer	Warm Fork 5
Camp Jefferson Hollow	3	Thayer	Bay Cr. 4
Anthony Branch	4	Thayer	Warm Fork 5
Cedar Hollow	4	Thayer	Anthony Br. 4
EPW072	3	Couch	Cedar Hollow 4
EPW073	3	Couch	Cedar Hollow 4
Culp Hollow	4	Rover	Warm Fork 5
Watered Rock Hollow	3	Rover	Culp Hollow 4
Orchard Branch	3	Rover	Warm Fork 5
James Branch	3	Rover	Warm Fork 5
Elk Creek	4	Brandsville	Warm Fork 5
Turkey Creek	3	Brandsville Elk Cr. 4	
EPW074	3	Brandsville Elk Cr. 4	
Howell Creek	5	Brandsville Warm Fork 5	
EPW075	3	Brandsville	Howell Cr. 5

Big Gressy Creek	3	Brandsville	Howell Cr. 5
EPW075a	3	Brandsville	Howell Cr. 5
Little Greasy Creek	3	West Plains	Howell Cr. 5
Mustion Creek	4	West Plains	Howell Cr. 5
EPW076	3	South Fork	Mustion Cr. 4
EPW077	3	South Fork	Mustion Cr. 4
Spradlin Creek	3	West Plains	Howell Cr. 5
South Fork Howell Creek	4	West Plains	Howell Cr. 5
Burton Creek	3	West Plains	S. F. Howell Cr. 4
North Fork Howell Creek	4	West Plains	Howell Cr. 5
Galloway Creek	4	White Church	N.F. Howell Cr. 4
EPW078	3	Pomona	Galloway Cr. 4
English Creek(Bussel Br.)	3*	Thayer	Spring R. AR
Bussel Branch	3	Koshkonong	Grand Gulf Sink
Presley Branch	3	Koshkonong	Myatt Cr. AR
Myatt Creek	5*	Koshkonong	Spring R. AR
Nail Creek	4	Koshkonong	Myatt Cr. 5
Hunt Branch	3	Lanton	Nail Cr. 4
Harmon Hollow	3	Koshkonong	Myatt Cr. 5

Sycamore Hollow	3	Lanton	Myatt Cr. 4
Stuart Hollow	3	Lanton	Myatt Cr. 4
South Fork Spring River	6*	Lanton	Spring R. AR
EPW079	3	Lanton	S.F. Spring R. 6
West Fork	5	Lanton	S.F. Spring R. 6
Elkhorn Branch	3	Lanton	West Fork 5
EPW080	3	Moody	West Fork 5
Mansfield Hollow	3	Moody	West Fork 5
Cabin Hollow	3	Moody	West Fork 5
Newberry Hollow	3	Moody	West Fork 5
EPW081	3	Moody	West Fork 5
Monk Branch	4	Moody	West Fork 5
EPW082	3	Moody	Monk Br. 4
EPW083	3	Moody	West Fork 4
EPW084	3	Moody	West Fork 4
EPW085	3	Moody	West Fork4
EPW086	3	Lanton	S.F. Spring R. 5
Wilson Hollow	3	Lanton	S.F. Spring R. 5
Hay Hollow	3	Lanton	S.F. Spring R. 5
EPW087	3	Lanton	S.F. Spring R. 5

Spring Creek	4	Moody	S.F. Spring R. 5
EPW088	3	South Fork	S.F. Spring R. 4
Bay Creek	3	Moody*	S.F. Spring R. AR

^{*} Order at State Line

Table Ge02. Length by order for fourth order and larger streams within the Spring River Tributaries Watershed.

	Lengt	Length by Order (miles)						
Stream Name	6	5	4	3	2	1	Total Miles	
Anthony Branch			0.5	5.3	-	-	5.8	
Barren Hollow		4.0	0.6	2.2	0.3	0.5	7.5	
Bay Creek			2.2	3.5	0.4	1.5	7.5	
Cedar Hollow			3.9	0.7	0.5	0.2	5.2	
Culp Hollow			0.4	5.5	0.7	0.5	7.2	
Elk Creek			5.5	2.1	1.0	0.3	8.9	
EPW069			0.8	0.8	0.6	0.3	2.5	
EPW070			0.8	0.7	0.05	0.7	2.3	
Galloway Creek			2.6	1.3	1.1	0.5	5.5	
Howell Creek		18.0	-	-	-	-	18.0	
Janes Creek		0.1	2.4	1.6	2.6	0.3	6.9	
Monk Branch			1.1	0.9	0.7	0.6	3.4	
Mustion Creek			8.1	1.2	.7	-	9.9	
Myatt Creek		2.9	6.0	11.4	0.6	1.8	22.7	
Nail Creek			0.9	1.6	1.2	0.9	4.6	
N.F. Howell Cr.			1.9	2.9	0.7	0.8	6.2	
S.F. Howell Cr.			1.0	1.6	1.5	0.7	4.8	
S.F. Janes Cr.			2.5	2.8	1.4	0.5	7.2	
South Fork	0.8	14.9	2.8	3.4	2.4	0.5	24.7	
Spring Creek			3.2	0.7	0.6	1.7	6.15	
Trace Creek			4.2	0.6	1.7	0.4	6.9	
Warm Fork.	5.4	18.3	-	-	-	-	23.6	
West Fork		9.5	4.9	0.6	0.1	0.8	15.9	
Total	6.2	67.7	56.3	51.4	18.9	13.5	213	

Table Ge03. Estimated length of permanent flowing water of third order and larger streams within the Spring River Tributaries Watershed, Missouri based on USGS 7.5 minute topographical maps.

Stream Name	Order	Miles Permanent		% Permanent
Anthony Branch	4	3.2	5.8	55
Barren Hollow	5	1.1	7.5	15
Bay Creek	4	1.5	7.5	20
Bussell Branch	3	5.2	15.0	35
Cox Creek	3	2.2	5.3	41
Hay Hollow	3	0.3	1.6	19
Helms Hollow	3	1.3	3.1	42
Howell Creek	5	17.2	18.0	95
Myatt Creek	5	4.8	22.7	21
Nail Creek	4	1.1	4.6	24
Presley Branch	3	0.9	3.3	27
South Fork	4	18.9	24.7	77
Spring Creek	4	6.1	6.1	100
Two Mile Creek	3	2.0	7.8	26
Warm Fork.	6	22.6	23.6	96
West Fork	5	11.4	15.9	72
Total		99.8	173	-

Table Ge04. Spring River Tributaries Watershed stream reaches designated as losing by the Missouri Department of Natural Resources (MDNR 1996b).

Stream	Miles	From	То
Elk Cr.	4.0	sw,se,se,24,24n,07w	se,ne,nw,08,23n,06w
Big Greasy Cr.	3.0	sw,ne,sw,28,24n,07w	nw,nw,nw,02,23n,07w
Mustion Cr.	3.5	ne,ne,se,32,24n,08w	sw,nw,se,36,24n,08w
Mustion Cr.	2.0	nw,ne,se,36,24n,09w	nw,se,ne,32,24n,083w
Chapin Br.	3.0	sw,nw,nw,14,23n,08w	ne,nw,se,06,23n,07w
Myatt Cr.	13.0	sw,se,nw,14,23n,08w	se,se,nw,33,22n,07w
L. Greasy Cr.	5.0	se,ne,13,24n,08w	nw,sw,se,05,23n07w
Bay Cr.	2.5	ne,sw,ne,32,22n,09w	se,sw,nw,10,21n,09w
Howell Cr.	16.0	ne,sw,nw,35,25n,09w	ne,ne,ne,12,23n,07w
Spradlin Cr.	3.0	ne,nw,nw,10,24n,08w	se,ne,sw,26,24n,08w
Galloway Cr. and Trib.	0.5	sw,sw,04,24n,08w	sw,ne,08,24n,08w
Spring R.	2.0	sw,se,se,20,22n,05w	se,se,sw,29,22n,05w
Warm Fork	6.0	nw,nw,nw,07,23n,06w	nw,ne,se,23,23n,06w
Water Br.	2.0	nw,ne,se,19,24n,06w	sw,sw,ne,31,24n,06w
English Cr.	2.5	sw,sw,sw,16,22n,06w	se,se,ne,33,22n,06w
Rover Br.	4.0	ne,27,24n,06w	se,se,se,31,24n,06w
Bussell Br.	5.0	nw,se,01,22n,07w	sw,sw,se,20,22n,06w
Trib to Bussell Cr.	1.5	nw,sw,05,22n,06w	nw,se,sw,07,22n,06w
Total	78.5		

Note: This table is not a final authority. Data subject to change.

Table Ge05. Named Springs of the Spring River Tributaries Watershed, Missouri. (Vineyard and Feder 1974; USGS Geographic Names Information System Data).

Name	County	USGS 7.5' Quad. Name	Discharge (cfs)
Aunt Cindy Spring	Howell	Moody	-
Batman Spring	Oregon	Thayer	-
Bunt Spring	Howell	Lanton	-
Cherry Spring	Howell	Moody	-
Childers Spring	Oregon	Thayer	-
Cold Rock Spring	Oregon	Rover	-
Eldorado Spring	Oregon	Couch	-
Gladden Spring	Howell	Moody	-
Heimer Spring	Oregon	Thayer	-
Hellberg Spring	Oregon	Thayer	-
Lapp Spring	Howell	Moody	-
Lost Spring	Howell	Moody	.02
Ragan Spring	Oregon	Rover	-
Ruprecht Spring	Oregon	Couch	-
Spout Spring	Oregon	Thayer	-
Underwood Spring	Oregon	Couch	-

Warm Fork Spring	Oregon	Rover	-
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Table Ge06. Stream gradient for order as well as average gradient for entire stream for fourth order and larger streams within the Spring River Tributaries Watershed. Streams highlighted are illustrated with composite gradient plots.

	Grad	Average Gradient					
Stream Name	6	5	4	3	2	1	(ft/mi)
A (1 - T) - 1					White	eoak/	
Anthony Branch			23	35	Ragai	n Hol.	33
Barren Hollow		25	27	56	114	193	48
Bay Creek			41	43	43	56	45
Cedar Hollow			37	54	110	202	52
Culp Hollow			26	37	40	98	41
Elk Creek			21	34	46	99	30
EPW069			38	59	96	200	77
EPW070			44	69	108	125	79
Galloway Creek			27	27	52	91	38
Howell Creek		11		Howell (Howell C			11
Janes Creek		14	25	29	52	149	41
Monk Branch			45	68	62	110	67
Mustion Creek			17	44	54	-	25
Myatt Creek		13	15	15	17	31	16
Nail Creek			22	50	49	133	60
N.F. Howell Cr.			18	28	62	89	37
S.F. Howell Cr.			26	31	33	74	37
S.F. Janes Cr.			22	36	39	75	35
South Fork	11	15	19	22	21	52	18
Spring Creek			33	7	25	38	31
Trace Creek			45	64	87	116	61

Warm Fork.	8	Howel	Howell Cr./Elk Cr.				
West Fork		17	30	36	38	53	23